

## **WHAT IS CLAIMED IS:**

1. A method of manufacturing a semiconductor structure, the method comprising:
    - providing a semiconductor substrate or substrate assembly;
    - providing a precursor composition comprising one or more complexes of the formula:
$$[(R^1)NC(R^2)C(R^3)N(R^4)]_xML_y$$
wherein:
      - M is a Group IVB, VB, or VIB metal;
      - each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> group is independently H or an organic group;
      - L is selected from the group of CO, NO, CN, CS, CNR<sup>5</sup>, R<sup>6</sup>CN, or R<sup>7</sup>, wherein each R<sup>5</sup>, R<sup>6</sup>, and R<sup>7</sup> group is independently an organic group;
    - x = 1 to 4; and
    - y = 1 to 4; andforming a metal-containing film from the precursor composition on a surface of the semiconductor substrate or substrate assembly.
  2. The method of claim 1 wherein the step of forming a metal-containing film comprises vaporizing the precursor composition and directing it toward the semiconductor substrate or substrate assembly using a chemical vapor deposition technique.
  3. The method of claim 2 wherein the chemical vapor deposition technique comprises flash vaporization, bubbling, microdroplet formation, or combinations thereof.

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4. The method of claim 2 wherein the precursor composition is vaporized in the presence of a carrier gas.
5. The method of claim 2 wherein the precursor composition is vaporized in the presence of a reaction gas.
6. The method of claim 5 wherein the reaction gas is selected from the group of H<sub>2</sub>, SiH<sub>4</sub>, Si<sub>2</sub>H<sub>6</sub>, NH<sub>3</sub>, N<sub>2</sub>H<sub>4</sub>, PH<sub>3</sub>, AsH<sub>3</sub>, GeH<sub>4</sub>, t-BuSbMe<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>Se, Te(allyl)<sub>2</sub>, and combinations thereof.
7. The method of claim 1 wherein each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> group is independently H or a (C<sub>1</sub>-C<sub>30</sub>)organic group.
8. The method of claim 1 wherein the complex is a monomer.
9. The method of claim 1 wherein each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> group is independently H or a (C<sub>1</sub>-C<sub>4</sub>)alkyl moiety.
10. The method of claim 1 wherein R<sup>7</sup> is cyclopentadienyl or a substituted cyclopentadienyl.
11. The method of claim 1 wherein the precursor composition is a liquid.
12. The method of claim 1 wherein the metal is a Group VB metal.
13. The method of claim 12 wherein the metal is vanadium.
14. The method of claim 1 wherein the metal-containing film is a Group IVB, VB, or VIB metal alloy film.

15. A method of forming a film on a substrate, the method comprising:

providing a substrate;

providing a precursor composition comprising one or more complexes of the formula:

$$[(R^1)NC(R^2)C(R^3)N(R^4)]_xML_y$$

wherein:

M is a Group IVB, VB, or VIB metal;

each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is independently H or an organic group;

L is selected from the group of CO, NO, CN, CS, CNR<sup>5</sup>, R<sup>6</sup>CN, or R<sup>7</sup>, wherein each R<sup>5</sup>, R<sup>6</sup>, and R<sup>7</sup> group is independently an organic group

x = 1 to 4; and

y = 1 to 4; and

forming a metal-containing film from the precursor composition on a surface of the substrate.

16. The method of claim 15 wherein the step of forming a metal-containing film comprises vaporizing the precursor composition and directing it toward the substrate using a chemical vapor deposition technique.

17. The method of claim 14 wherein the precursor composition is liquid.

18. A chemical vapor deposition system comprising:

a deposition chamber having a substrate positioned therein;

a vessel containing a precursor comprising one or more complexes of the formula:

$$[(R^1)NC(R^2)C(R^3)N(R^4)]_xML_y$$

wherein:

M is a Group IVB, VB, or VIB metal;

each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is independently H or an organic group;

L is selected from the group of CO, NO, CN, CS, CNR<sup>5</sup>, R<sup>6</sup>CN, or R<sup>7</sup>, wherein each R<sup>5</sup>, R<sup>6</sup>, and R<sup>7</sup> group is independently an organic group;

x = 1 to 4; and

y = 1 to 4; and

a source of an inert carrier gas for transferring the precursor to the chemical vapor deposition chamber.

19. A chemical vapor deposition system comprising:
- a deposition chamber having a substrate positioned therein;
  - a vessel containing a precursor composition comprising one or more complexes of the formula:
- $$[(R^1)NC(R^2)C(R^3)N(R^4)]_xML_y$$
- wherein:
- M is a Group IVB, VB, or VIB metal;
  - each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is independently H or an organic group;
  - each L is independently CO, NO, CN, CS, CNR<sup>5</sup>, R<sup>6</sup>CN, or R<sup>7</sup>, wherein each R<sup>5</sup>, R<sup>6</sup>, and R<sup>7</sup> group is independently an organic group;
  - x = 1 to 4; and
  - y = 1 to 4.
20. The system of claim 19 wherein the deposition chamber is adapted for forming a metal-containing film comprising vaporizing the precursor composition and directing it toward the semiconductor substrate or substrate assembly using a chemical vapor depositional technique.
21. The system of claim 20 wherein the chemical vapor deposition technique comprises flash vaporization, bubbling, microdroplet formation, or combinations thereof.
22. The system of claim 20 wherein the precursor composition is vaporized in the presence of a carrier gas.
23. The system of claim 20 wherein the precursor composition is vaporized in the presence of a reaction gas.

24. The system of claim 23 wherein the reaction gas is selected from the group of H<sub>2</sub>, SiH<sub>4</sub>, Si<sub>2</sub>H<sub>6</sub>, NH<sub>3</sub>, N<sub>2</sub>H<sub>4</sub>, PH<sub>3</sub>, AsH<sub>3</sub>, GeH<sub>4</sub>, t-BuSbMe<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>Se, Te(allyl)<sub>2</sub>, and combinations thereof.
25. The system of claim 19 wherein each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> group is independently H or a (C<sub>1</sub>-C<sub>30</sub>)organic group.
26. The system of claim 19 wherein the complex is a monomer.
27. The system of claim 19 wherein each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> group is independently H or a (C<sub>1</sub>-C<sub>4</sub>)alkyl moiety.
28. The system of claim 19 wherein R<sup>7</sup> is cyclopentadienyl or a substituted cyclopentadienyl.
29. The system of claim 19 wherein the precursor composition is a liquid.
30. The system of claim 19 wherein the metal is a Group VB metal.
31. The system of claim 30 wherein the metal is vanadium.
32. The system of claim 19 wherein the metal-containing film is a Group IVB, VB, or VIB metal alloy film.  
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33. A chemical vapor deposition system comprising:
  - a deposition chamber having a semiconductor substrate or substrate assembly positioned therein;
  - a vessel containing a precursor composition comprising one or more complexes of the formula:
$$[(R^1)NC(R^2)C(R^3)N(R^4)]_xML_y$$

wherein:

M is a Group IVB, VB, or VIB metal;  
 each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is independently H or an organic group;  
 each L is independently CO, NO, CN, CS, CNR<sup>5</sup>, R<sup>6</sup>CN, or R<sup>7</sup>, wherein each R<sup>5</sup>, R<sup>6</sup>, and R<sup>7</sup> group is independently an organic group;  
 x = 1 to 4; and  
 y = 1 to 4.

- 34. The system of claim 33 wherein each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> is independently H or a (C<sub>1</sub>-C<sub>30</sub>)organic group.
- 35. The system of claim 33 wherein the complex is a monomer.
- 36. The system of claim 33 wherein each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> group is independently H or a (C<sub>1</sub>-C<sub>4</sub>)alkyl moiety.
- 37. The system of claim 33 wherein R<sup>7</sup> is cyclopentadienyl or a substituted cyclopentadienyl.
- 38. A chemical vapor deposition system comprising:
  - a deposition chamber having a semiconductor substrate or substrate assembly positional therein;
  - a vessel containing a precursor composition comprising one or more liquid complexes of the formula:
 
$$[(R^1)NC(R^2)C(R^3)N(R^4)]_x ML_y$$
 wherein:
 

M is a Group IVB, VB, or VIB metal;  
 each R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, and R<sup>4</sup> independently H or a (C<sub>1</sub> -

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$C_{30}$ )organic group;  
each L is independently CO, NO, CN, CS,  $CNR^5$ ,  $R^6CN$ , or  
 $R^7$ , wherein each  $R^5$ ,  $R^6$ , and  $R^7$  group is independently an  
organic group;  
 $x = 1$  to 4; and  
 $y = 1$  to 4.